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EXPLORING THE NEXUS BETWEEN WEATHER VARIABLES AND WHEAT QUALITY ACROSS DIFFERENT SOWING DATES AND VARIETIES: A COMPREHENSIVE CORRELATION STUDY

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ABSTRACT

This research delved into the intricate interplay between weather variables and wheat quality across diverse sowing dates, conducted at the Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India during the *rabi* season of 2021-22. Employing a split plot design with three replications, the study investigated five distinct sowing dates as main plot treatments: 20th November (S₁), 30th November (S₂), 10th December (S₃), 20th December (S₄) and 30th December (S₅). The sub-plot comprised three different wheat varieties: V₁: GW 451, V₂: GW 496 and V₃: GW 499. Critical parameters of wheat quality, including protein content, wet gluten content, starch content, moisture content, sedimentation value and hectoliter weight were scrutinized, revealing correlations with an array of weather variables spanning from the earliest to the delayed sowing dates. Elevated temperatures, bright sunshine hours (BSS) and evaporation rates were found to diminish grain yields, whereas heightened morning and evening humidity levels enhanced yields. Wet gluten content, protein content and sedimentation value exhibited positive correlations with maximum-minimum temperatures, BSS and total evaporation, yet were adversely impacted by humidity and total rainfall. Conversely, moisture content demonstrated weaker associations with weather factors. Starch content and hectoliter weight displayed negative correlations with temperature, BSS and total evaporation, while exhibiting positive correlations with humidity and total rainfall. These findings underscored the substantial influence of meteorological parameters in determining both crop yield and quality. Notably, highest levels of protein content, wet gluten content and sedimentation value was obtained from final sowing date, 30th December, while starch content and hectoliter weight peaked when the crop was sown on 20th November. Protein content, moisture content, wet gluten content and sedimentation value were not significantly affected by different varieties. However, starch content was notably higher in GW 496 and GW 451 varieties, while GW 499 exhibited the highest hectoliter weight.

Key words : Wheat, Quality parameters, Weather variables, Sowing date, Varieties.

Introduction

Wheat thrives in various climates, preferring dry and cool conditions. Require a 20-25°C temperature range for germination and ideal humidity is 50-60%. Excessive rain after sowing hampers the germination of seeds. Cultivation duration ranges from 100 days in the south to 180 days in the hills. Heat during ripening causes grain shriveling. This research investigates the impact of weather variables (temperature, humidity, bright sunshine hours, rainfall and evaporation) on wheat yield and quality

parameters. Fluctuations in crop production during the reproductive phase are attributed to several meteorological factors (Kingra, 2016). A significant global constraint on wheat quality has been influenced by unfavourable environmental conditions during anthesis and the grain filling period, extreme temperature and drought during grain filling have been identified as a major source of variation in wheat flour quality characteristics (Singh *et al.*, 2010). The expression of grain quality varies from site to site as a result of the strong dependence of

many quality characteristics on environmental factors. In fact, it is known that climatic factors have an impact on grain protein content, which is possibly the most significant quality characteristic of wheat (Rharrabti *et al.*, 2003). The quality of food products is significantly influenced by starch, which is the main component of wheat flour. It serves as the source of carbon during yeast fermentation in bread making (Singh *et al.*, 2010). Changes in the meteorological parameters have an impact on the development and growth of the crop and indicate diminishing trends in yield (Aravind *et al.*, 2022). Wheat yield and grain quality are significantly impacted by drought and heat stress during the grain growth and development stages of crops, particularly in terms of protein content. The two most crucial factors that are significantly impacted by changes in sowing time are grain protein and gluten quality (Ahmed and Fayyaz-ul-Hassan, 2015). The quality of wheat grains is influenced by various factors, including genetic characteristics, agronomic practices and environmental conditions. Among these factors, weather parameters and sowing times play a crucial role in determining the final quality attributes and yield of wheat (Anureet *et al.*, 2010). Another important aspect is lack of improved varieties, the choice of wheat varieties affects important quality factors like protein content and gluten strength, which affects the nutritional value and baking qualities of products made from wheat. This emphasises the significance of selecting suitable varieties suited to particular intended end products. Different varieties respond differently for their genotypic characters, input requirement, growth process and the prevailing environment during growing season (Sultana *et al.*, 2012).

Assessing the quality parameters (Protein content, wet gluten content, starch content, moisture content, sedimentation value and hectoliter weight) of wheat is essential as they determine the end-use suitability of wheat grains for various applications, including milling, baking and food processing industries. Here are some findings related to quality parameters: The delayed crop sowing significantly increased the protein content of wheat grains, the hectoliter weight decreased significantly with delayed crop sowing, the wet gluten content of wheat grain was increased significantly with delay in sowing dates (Anureet *et al.*, 2010). There is evidence that the amount of total starch decreases as temperature rises (Zhang *et al.*, 2023). Impact of weather variables on quality parameters informs decisions on sowing, variety selection and crop management. This knowledge fosters climate-resilient wheat varieties and sustainable agriculture.

Materials and Methods

The field experiment was laid out in Plot A-6 at the Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India (22.58° N latitude and 72.92° E and 45.1 mm above the mean sea level) during the *rabi* seasons of 2021-22. This centre is located in the Middle Gujarat Agro-Climatic Zone of Gujarat. The region experiences a semi-arid and sub-tropical climate. The average annual rainfall is 864.5 mm, with the rainy season lasting from the middle of June to the middle of September. Anand is approximately 70 km away from the Arabian Sea Coast, resulting in a typical sub-tropical climate. The temperature during the rainy season ranges from 20°C to 35°C, with higher temperatures reaching up to 37°C in October. Winter begins in December and continues until February, with January being the coldest month. The summer season starts in the second fortnight of February and ends in the middle of June. Summers are hot and dry, particularly in April and May. The soil was loamy sand in texture. The experimental design employed a split plot design with three replications and 15 treatment combinations, where main plot consisted of five different sowing times: S₁: 20th November; S₂: 30th November; S₃: 10th December; S₄: 20th December and S₅: 30th December and the sub-plot consisted of three different wheat varieties: GW 451, GW 496 and GW 499. The first irrigation was given just after sowing and the remaining irrigations were given as and when required by the crop. Quality Parameters such as protein content, moisture content, starch content, sedimentation value (ml) and wet gluten content were analyzed using the INFRATEC™ 1241 GRAIN ANALYZER (Fig. 1). Hectoliter weight (kg/hl) was determined using the Hectoliter Weight Kit (Fig. 2). The



Fig. 1 : INFRATEC™ 1241 Grain Analyzer.



Fig. 2 : Hectoliter Weight kit.

Table 1 : Weather data recorded during crop season of the year 2021-22 (weekly mean).

| Months | Std. week | Temp. (°C) | | RH (%) | | Bright sunshine hours (BSS) (hrs./day) | Rainfall (mm/day) | Evaporation (mm/day) |
|---------------|-----------|------------|------|--------|------|--|-------------------|----------------------|
| | | Max. | Min. | Mor. | Eve. | | | |
| November 2021 | 45 | 32.8 | 17.0 | 67 | 28 | 8.2 | 0 | 3.5 |
| | 46 | 31.2 | 18.0 | 62 | 36 | 7.2 | 0 | 4.3 |
| | 47 | 31.7 | 20.7 | 84 | 50 | 6.0 | 0 | 3.3 |
| | 48 | 30.6 | 16.4 | 83 | 53 | 7.0 | 1.6 | 2.9 |
| December 2021 | 49 | 26.1 | 17.6 | 86 | 62 | 4.4 | 0.3 | 1.8 |
| | 50 | 28.1 | 16.5 | 80 | 49 | 6.5 | 0 | 2.6 |
| | 51 | 26.6 | 11.2 | 78 | 38 | 8.3 | 0 | 3.2 |
| | 52 | 26.4 | 14.3 | 90 | 56 | 6.7 | 0.1 | 2.1 |
| January 2022 | 01 | 26.4 | 14.0 | 91 | 58 | 5.0 | 0 | 2.3 |
| | 02 | 23.9 | 11.1 | 87 | 39 | 8.7 | 0 | 3.1 |
| | 03 | 26.7 | 12.9 | 90 | 49 | 8.7 | 0 | 2.5 |
| | 04 | 24.5 | 10.4 | 84 | 42 | 7.6 | 0 | 3.2 |
| | 05 | 28.8 | 10.9 | 88 | 37 | 8.8 | 0 | 2.9 |
| February 2022 | 06 | 29.0 | 12.4 | 86 | 33 | 9.0 | 0 | 3.4 |
| | 07 | 30.1 | 13.4 | 77 | 32 | 9.7 | 0 | 3.8 |
| | 08 | 32.2 | 14.2 | 83 | 37 | 9.8 | 0 | 4.6 |
| | 09 | 33.6 | 16.8 | 75 | 29 | 9.6 | 0 | 5.2 |
| March 2022 | 10 | 34.5 | 18.2 | 70 | 30 | 8.7 | 0 | 5.2 |
| | 11 | 38.2 | 19.0 | 70 | 26 | 9.7 | 0 | 6.8 |
| | 12 | 37.7 | 22.2 | 60 | 27 | 7.1 | 0 | 7.4 |
| | 13 | 38.6 | 20.8 | 84 | 29 | 9.1 | 0 | 6.6 |

weather variables that prevailed during the experiment were obtained from the Department of Agricultural Meteorology, Anand Agricultural University, Anand Gujarat India.

Statistical analysis

The statistical analysis of the data generated (Table 3) during the course of investigation was carried out through software on computer following the procedure described by Cochran and Cox (1967) by computer system at the computer centre, B. A. College of Agriculture, Anand. The variances of different sources of variation in ANOVA were tested by “F-test” and compared with the value of Table F at 5% level of significance. SEM \pm , critical differences and co-efficient of variation (CV %) were also worked out.

A statistical analysis of the correlation of weather data with yield and quality parameters (Table 2) was conducted using Python software. The correlation coefficients were calculated to evaluate the relationships

between different variables. The Person correlation coefficients were computed for each variable pair and the significance levels were determined.

Results and Discussion

Effect of weather variables and sowing dates on quality parameters and grain yield

Quality of grain in wheat production is very important in view of industries and consumer preference. The correlation of yield and quality parameters with weather variables is delineated in Table 2. The data of different quality parameters in wheat grain as influenced by different dates of sowing are presented in Table 3.

Protein content

Protein content significantly increased with delayed sowing. Significantly the highest protein content (13.86%) was found in sowing date 30th December (S5). Whereas, sowing date 30th November noticed significantly lower protein content (%) followed by treatment S₁ (20th

Table 2 : Correlation of yield and quality parameters with weather variables.

| | | Max Temp. | Min. Temp. | RH % (mor.) | RH % (eve.) | BSS | Total rainfall | Total evaporation |
|----------------------------------|---------------------|-----------|------------|-------------|-------------|----------|----------------|-------------------|
| Protein content | Pearson Correlation | 0.891** | 0.849** | -0.754** | -0.843** | 0.790** | -0.720** | 0.702** |
| | Sig. (2-tailed) | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.002 | 0.004 |
| Moisture content | Pearson Correlation | -0.442 | -0.469 | 0.398 | 0.382 | -0.316 | 0.120 | -0.433 |
| | Sig. (2-tailed) | 0.099 | 0.078 | 0.141 | 0.160 | 0.252 | 0.671 | 0.107 |
| Starch content | Pearson Correlation | -0.612* | -0.525* | 0.485 | 0.618* | -0.606* | 0.582* | -0.291 |
| | Sig. (2-tailed) | 0.015 | 0.044 | 0.067 | 0.014 | 0.017 | 0.023 | 0.293 |
| Wet gluten content | Pearson Correlation | 0.831** | 0.810** | -0.728** | -0.779** | 0.729** | -0.689** | 0.729** |
| | Sig. (2-tailed) | 0.000 | 0.000 | 0.002 | 0.001 | 0.002 | 0.005 | 0.002 |
| Sedimentation value (ml) | Pearson Correlation | 0.847** | 0.702** | -0.750** | -0.854** | 0.832** | -0.780** | 0.631* |
| | Sig. (2-tailed) | 0.000 | 0.004 | 0.001 | 0.000 | 0.000 | 0.001 | 0.012 |
| Hectoliter weight (kg/hl) | Pearson Correlation | -0.958** | -0.833** | 0.901** | 0.941** | -0.897** | 0.821** | -0.901** |
| | Sig. (2-tailed) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Grain yield (kg/ha) | Pearson Correlation | -0.909** | -0.753** | 0.883** | 0.919** | -0.876** | 0.824** | -0.786** |
| | Sig. (2-tailed) | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

November). Based on the data presented in Table 3, percentage differences indicated that S₅ (30th December) had 18.77, 15.21, 12.77 and 8.45 per cent higher protein content than treatments S₂ (30th November), S₁ (20th November), S₃ (10th December) and S₄ (20th December), respectively.

Table 2 indicates that the protein content exhibited strong positive correlations with max. temp. ($r = 0.891^{**}$) and min. temp. ($r = 0.849^{**}$) and significant negative correlations with RH% (mor.) ($r = -0.754^{**}$) and RH% (eve.) ($r = -0.843^{**}$). BSS demonstrated a strong positive correlation with protein content ($r = 0.790^{**}$) and a significant inverse relationship with total rainfall ($r = -0.720^{**}$). Additionally, total evaporation had a significant positive correlation with protein content ($r = 0.702^{**}$). All the correlations mentioned were significant at the 0.01 level, indicating a strong relationship between the quality parameters and meteorological conditions. These findings suggest that temperature, humidity, BSS, rainfall and evaporation influence the protein content of the wheat grain.

An increase in the amount of protein content in wheat grain with delayed crop sowings might have been caused by rise in temperature, which encouraged the synthesis of amino acids while also hindering grain development or causing wheat grains to become shrivelled, resulting in higher protein content. The findings agree with those reported by Anureet *et al.* (2010) and Patel *et al.* (2018).

Moisture content

Moisture percentage of wheat after harvest was found to be non-significant due to different dates of sowing. It might be due to proper drying after harvesting (Table 3).

Results provided in Table 2 indicate that there is a negative correlation between temperature (maximum and minimum) and moisture content. However, these correlations are not statistically significant. Similarly, positive correlations exist between relative humidity (morning and evening) and moisture content, but they are also not statistically significant. Additionally, there is a negative correlation between the bright sunshine hours and moisture content, which is not statistically significant. Moreover, there is no significant correlation between total rainfall and moisture content. Lastly, a negative correlation exists between total evaporation and moisture content, but it is not statistically significant.

Moisture content was not statistically influenced by the different weather variables. It might happen as a result of proper drying after harvesting. The moisture percentage was not affected by sowing time (Anureet *et al.*, 2010).

Starch content

Significantly higher starch (DM) content was recorded with 30th November (63.23%) sowing which was also at par with 20th November, 10th December and

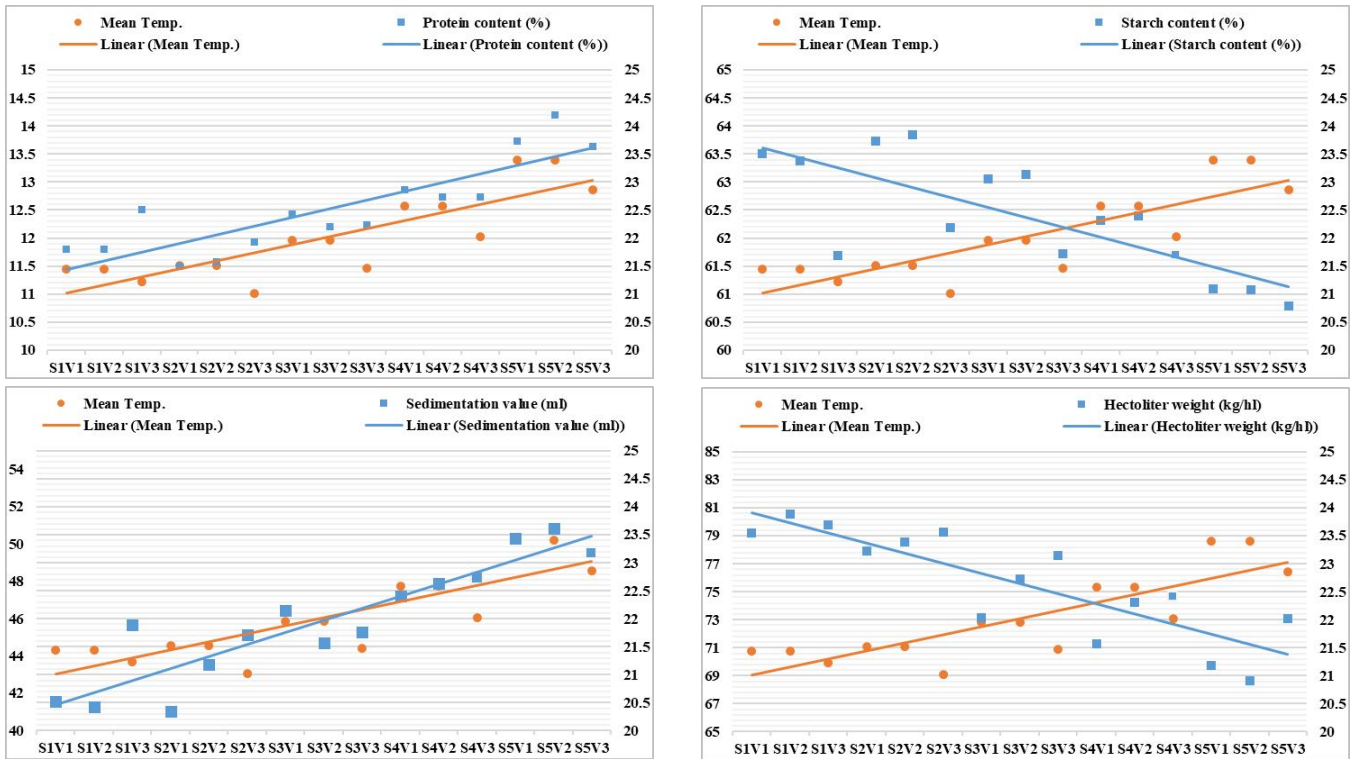


Fig. 3 : Correlation of quality parameters of wheat with mean temperature (°C).

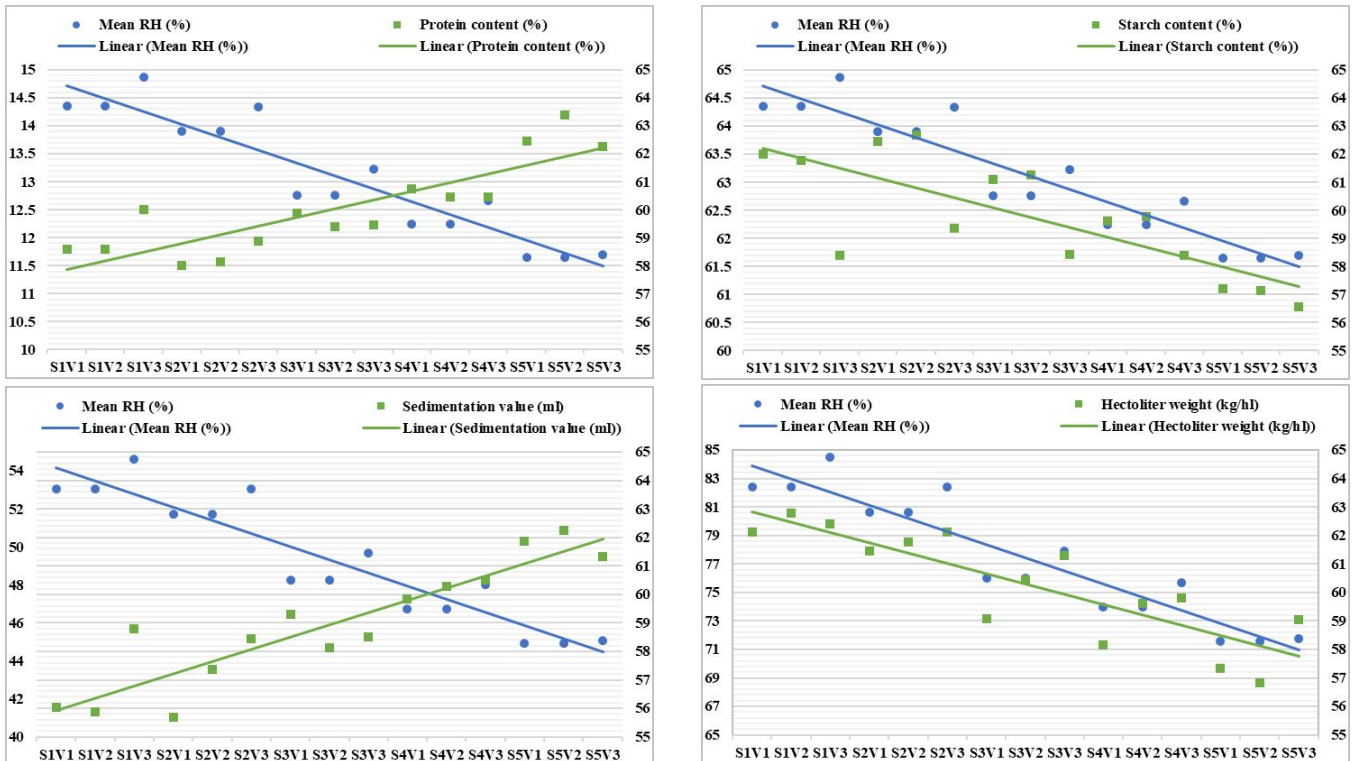


Fig. 4 : Correlation of quality parameters of wheat with mean relative humidity (%).

20th December sowing. Whereas, significantly lower starch (DM) content was measured in 30th December sowing (60.99%), which was at par with treatment S₄ (Table 3).

Data presented in Table 2 revealed that maximum

temperature (-0.612*) and minimum temperature (-0.525*) negatively correlate with starch content, indicating that higher temperatures are associated with lower starch content. Morning relative humidity (0.485) and evening relative humidity (0.618*) positively correlates with starch

content. BSS shows a significant negative correlation (-0.606^*) with starch content, suggesting a potential inhibitory effect. Total rainfall (0.582^*) positively correlates with starch content, while total evaporation (-0.291) does not show a significant relationship. These findings suggest that temperature, humidity, BSS, rainfall and evaporation influence the starch content of the wheat grain.

A reduction in the amount of starch content in wheat grain with delayed crop sowings might have been caused by high temperatures after flowering, resulting in low starch content in late sowing dates. The findings agree with those reported by (Hakim *et al.*, 2012).

Wet gluten content

Treatment S_5 (30th December) reported significantly the highest value of wet gluten content (34.52%). While treatment S_2 (30th November) found significantly lower and it was also at par with treatment S_1 (20th November). Wet gluten content is directly correlated with protein content and due to that late sowing reported higher wet gluten, which was also reflected in protein content (Table 3).

The results indicate significant positive correlations between wet gluten content and maximum temperature ($r = 0.831^{**}$), minimum temperature ($r = 0.810^{**}$), bright sunshine hours ($r = 0.729^{**}$) and total evaporation ($r = -0.729^{**}$). Conversely, there were significant negative correlations with relative humidity in the morning ($r = -0.728^{**}$) and relative humidity in the evening ($r = -0.779^{**}$). These findings suggest that higher temperatures, increased bright sunshine hours and lower humidity levels are associated with higher wet gluten content.

The significant increase in wet gluten might be due to the dilution effect of timely sown crops (Anureet *et al.*, 2010).

Sedimentation value (ml)

Sedimentation value (50.22 ml) found significantly the highest in the 30th December sowing (S_5). 20th November sowing (S_1) reported significantly lower sedimentation value (42.84 ml), being at par with 30th November (S_2) (43.26 ml) sowing date (Table 3).

The maximum temperature ($r = 0.847^{**}$) and minimum temperature ($r = 0.702^{**}$) recorded a strong positive correlation with the sedimentation value, indicating that as the maximum and minimum temperatures increased, the sedimentation value also increased. On the other hand, relative humidity in the morning and evening displayed strong negative correlations with the

sedimentation value ($r = -0.750^{**}$; $r = -0.854^{**}$, respectively), suggesting that higher humidity levels were associated with lower sedimentation values. The sedimentation value showed a strong positive correlation ($r = 0.832^{**}$) with the bright sunshine hours (BSS). Additionally, there was a significant negative correlation between the sedimentation value and total rainfall ($r = -0.780^{**}$). Lastly, there was a marginally positive correlation between total evaporation and sedimentation value ($r = 0.631^*$).

The significant increase in sedimentation value (Zeleny content) might be due to the dilution effect of timely sown crops (Anureet *et al.*, 2010).

Hectoliter weight

Significantly higher hectoliter weight (79.87 kg/hl) was recorded in 20th November (S_1) sown crop and which was at par with 30th November (S_2) (78.59 kg/hl) sowing. Significantly the lowest hectoliter weight (70.48 kg/hl) was observed in 30th December (S_5) sown crop (Table 3).

Table 2 shows that the hectoliter weight has a strong negative correlation with maximum temperature (-0.958^{**}), minimum temperature (-0.833^{**}) and BSS (-0.897^{**}), meaning that as the temperatures and BSS increase, the hectoliter weight tends to decrease. As opposed to that, the hectoliter weight has a strong positively correlated with relative humidity in the morning (0.901^{**}), evening (0.941^{**}) and total rainfall ($r = 0.821^{**}$) indicating that higher humidity and rainfall are associated with higher hectoliter weight. Lastly, there is a strong negative correlation between the hectoliter weight and total evaporation (-0.901^{**}), implying that higher evaporation is linked to lower hectoliter weight.

Lower hectoliter weight with higher temperature might be due to the higher thermal regime that prevailed in delayed-sown crops during the time of grain filling, the reduction in hectoliter weight may be the result of forced maturation and drying of immature seeds (Anureet *et al.*, 2010). The reduction in hectolitre weight observed with delayed crop sowings was possibly a result of a shorter crop season and the crop suffered from hot winds and high temperatures during the grain-filling period. As a result, small and shrivelled grains were produced. The findings agree with those reported by Yusuf *et al.* (2019).

Grain yield

Table 2 showed that grain yield have strong negative correlations with temperatures (maximum and minimum) and total evaporation, while relative humidity (morning and evening) have strong positive correlations. Bright sunshine hours have a negative correlation. Total rainfall

Table 3 : Quality parameters of wheat as influenced by different date of sowing and varieties (2021-22).

| Treatments | Protein content (%) | Moisture content (%) | Starch content (%) | Wet gluten content(%) | Sedimentation value (ml) | Hectoliter weight (kg/hl) |
|--|---------------------|----------------------|--------------------|-----------------------|--------------------------|---------------------------|
| Main plot : Date of sowing (S) | | | | | | |
| S ₁ : 20 th November | 12.03 | 12.98 | 62.87 | 32.07 | 42.84 | 79.87 |
| S ₂ : 30 th November | 11.67 | 12.67 | 63.23 | 31.31 | 43.26 | 78.59 |
| S ₃ : 10 th December | 12.29 | 13.28 | 62.64 | 32.76 | 45.47 | 75.54 |
| S ₄ : 20 th December | 12.78 | 12.48 | 62.14 | 32.76 | 47.79 | 73.39 |
| S ₅ : 30 th December | 13.86 | 12.42 | 60.99 | 34.52 | 50.22 | 70.48 |
| S.Em. ± | 0.13 | 0.20 | 0.43 | 0.38 | 0.58 | 0.68 |
| C.D. at 5% | 0.42 | NS | 1.40 | 1.24 | 1.89 | 2.23 |
| C.V.(%) | 3.10 | 4.77 | 2.06 | 3.49 | 3.80 | 2.72 |
| Sub plot : Varieties (V) | | | | | | |
| V ₁ : GW 451 | 12.47 | 12.77 | 62.74 | 32.98 | 45.31 | 74.26 |
| V ₂ : GW 496 | 12.50 | 12.62 | 62.76 | 32.58 | 45.67 | 75.58 |
| V ₃ : GW 499 | 12.61 | 12.90 | 61.63 | 32.49 | 46.77 | 76.88 |
| S.Em.± | 0.09 | 0.11 | 0.32 | 0.21 | 0.43 | 0.37 |
| C.D. at 5% | NS | NS | 0.94 | NS | NS | 1.09 |
| Interaction (S×V) | | | | | | |
| S.Em. ± | 0.20 | 0.25 | 0.72 | 0.47 | 0.97 | 0.83 |
| C.D. at 5% | NS | NS | NS | NS | NS | NS |
| C.V.(%) | 2.76 | 3.45 | 1.99 | 2.48 | 3.66 | 1.89 |

has positive correlations. These findings emphasize the importance of weather variables in determining crop yields.

Wheat was sown in time to protect it from heat stress and the crop also benefited from more favourable weather conditions, which improved the growth and yield characteristics, leading to a higher yield. The findings agree with those reported by Akhtar *et al.* (2012), Patel *et al.* (2018), Dar *et al.* (2020), Mehta and Dhaliwal (2020), Singh *et al.* (2021) and Singh *et al.* (2022).

Effect of varieties on quality parameters of wheat

The data of different quality parameters in wheat grain as influenced by varieties are presented in Table 3. The starch content of wheat crop was found to be significant by different varieties. Variety GW 496 (62.76%) recorded significantly higher starch content followed by variety GW 451 (62.74%). While variety GW 499 found significantly the lowest in starch content (61.63%). It might be due to genetic makeup of different varieties. Similar findings by Hakim *et al.* (2012).

It was revealed that different varieties had significant effect on hectoliter weight of wheat crop. It was found that variety GW 499 produced significantly the highest hectoliter weight (76.88 kg/hl). It might be due to the genetic makeup of varieties. Similar findings by Yusuf *et al.* (2019).

Different varieties failed to show their significant effect on protein content (%), Moisture Content (%), wet gluten content (%), sedimentation value (ml) of wheat.

Conclusion

This research study has established significant correlations between meteorological parameters and yield/quality parameters of wheat crop. The findings highlight the crucial role of weather variables on quality parameters, wherein higher temperatures, BSS and total evaporation have a negative impact on grain yield, but favor higher protein content, wet gluten content and sedimentation value. On the other hand, higher humidity and total rainfall positively influence yield but adversely affect protein content, wet gluten content and sedimentation value. While moisture displays weaker correlations with meteorological factors, indicating the presence of other influential factors. Furthermore, starch content and hectoliter weight are negatively affected by maximum temperature, minimum temperature and BSS. However, starch content and hectoliter weight have been positively impacted by relative humidity in both the morning and evening, as well as total rainfall. These findings emphasise the significant role of meteorological parameters in determining crop yield and quality. In terms of sowing date and varieties, the last sowing date, 30th December, resulted in the highest protein content, wet

gluten content and sedimentation value. However, starch content was significantly higher when the crop was sown on the 30th November, Furthermore, hectoliter weight (kg/hl) was significantly higher when the crop was sown on 20th November. Moisture content was not influenced by the different dates of sowing. Protein content, moisture content, wet gluten content and sedimentation value were significantly not influenced due to different varieties. However, starch content was recorded significantly higher in variety GW 496 followed by variety GW 451. Whereas, variety GW 499 found significantly the highest in hectoliter weight.

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Competing interests

The authors declare that there is no conflict of interest related to this article.

Author's contributions

Mihir B. Modh: Conceptualization, Methodology, data collection, Analysis, Writing, editing. Vinod B. Mor: Conceptualization, discussion, Review and editing, Supervision.

References

- Ahmed, M. and Fayyaz-ul-Hassan (2015). Response of spring wheat (*Triticum aestivum* L.) quality traits and yield to sowing date. *PloS One*, **10** (4), e0126097. <https://doi.org/10.1371/journal.pone.0126097>
- Akhtar, M., Iqbal R.M., Jamil M. and Akhtar L.H. (2012). Effect of sowing date on emergence, tillering and grain yield of different wheat varieties under Bahawalpur conditions. *Pak. J. Agri. Sci.*, **49**(3), 255-259.
- Anureet, K., Pannu R.K. and Buttar G.S. (2010). Quality of wheat (*Triticum aestivum* L.) as influenced by sowing dates and nitrogen scheduling. *Indian J. Agric. Sci.*, **80** (9), 781-785.
- Aravind, K.S., Vashisth A., Krishnan P. and Das B. (2022). Wheat yield prediction based on weather parameters using multiple linear, neural network and penalised regression models. *J. Agrometeorol.*, **24** (1), 18-25. <https://doi.org/10.54386/jam.v24i1.1002>
- Cochran, W.G and Cox G.M. (1967). *Experimental Designs*. John Wiley and Sons. Inc. New York: 546-568.
- Dar, S.B., Kanth R.H., Raja W., Bangroo S.A., Rashid Z., Dar Z.A. and Wani S.H. (2020). Performance of wheat variety Shalimar Wheat-2 under rainfed conditions of temperate Kashmir as influenced by sowing dates and nitrogen levels. *J.C.R.*, **12**(2), 129-136. <http://dx.doi.org/10.25174/2582-2675/2020/100138>
- Hakim, M.A., Hossain A., da Silva J.A.T., Zvolinsky V.P. and Khan M.M. (2012). Protein and starch content of 20 wheat (*Triticum aestivum* L.) genotypes exposed to high temperature under late sowing conditions. *J. Sci. Res.*, **4** (2), 477-477. <http://dx.doi.org/10.3329/jsr.v4i2.8679>
- Kingra, P.K. (2016). Climate variability impacts on wheat productivity in central Punjab. *J. Agrometeorol.*, **18**(1), 97-99. <https://doi.org/10.54386/jam.v18i1.909>
- Mehta, Purnima and Dhaliwal L.K. (2020). Effect of different sowing dates on helio-thermal, photo-thermal, heat use efficiencies and productivity of wheat (*Triticum aestivum* L.). *J. Agric. Phys.*, **20**(1), 106-119.
- Patel, M.D., Dabhi M.S., Patel A.K., Desai H.A. and Ram C. (2018). Response of wheat varieties (*Triticum aestivum* L. and *Triticum durum* Desf.) to sowing time. *Int. J. Curr. Microbiol. Appl. Sci.*, **7**, 1555-1561. <https://doi.org/10.20546/ijcmas.2018.710.174>
- Rharrabti, Y., Villegas D., Royo C., Martos-Núñez V. and Del Moral L.G. (2003). Durum wheat quality in Mediterranean environments: II. Influence of climatic variables and relationships between quality parameters. *Field Crops Res.*, **80**(2), 133-140. [http://dx.doi.org/10.1016/S0378-4290\(02\)00177-6](http://dx.doi.org/10.1016/S0378-4290(02)00177-6)
- Singh, D.P., Chandra V. and Tiwari T. (2022). Effect of sowing dates on yield and yield components of wheat in Maharajanj district Eastern UP. *J. Pharm. Innov.*, **11**(1), 228-231
- Singh, P.K., Singh S.K. and Singh, V. (2021). Effect of different sowing dates and cultivars on growth, yield and economics of wheat (*Triticum aestivum* L.) under mid land situation. *J. Pharm. Innov.*, **10**(8), 339-342
- Singh, S., Gupta A.K., Gupta S.K. and Kaur N. (2010). Effect of sowing time on protein quality and starch pasting characteristics in wheat (*Triticum aestivum* L.) genotypes grown under irrigated and rain-fed conditions. *Food Chem.*, **122**(3), 559-565. <http://dx.doi.org/10.1016/j.foodchem.2010.03.010>
- Sultana, M.R., Alim M.A., Hossain M.B., Karmaker S. and Islam M.S. (2012). Effect of variety and weed management practices on yield and yield attributes of wheat. *J. Environ. Sci. Nat. Resources*, **5**(2), 91-96.
- Yusuf, M, Kumar S., Dhaka A.K., Singh B. and Bhuker A. (2019). effect of sowing dates and varieties on yield and quality performance of wheat (*Triticum aestivum* L.). *A. S. D.*, **39**, 306-310.
- Zhang, Z., Jia D., Wang D., Zhou N., Xing Z., Xu K. and Zhang H. (2023). Starch and Dough-Related Properties of Wheat (*Triticum aestivum* L.) Exposed to Varying Temperatures and Radiations after Anthesis. *Agronomy*, **13**(4), 1069. <https://doi.org/10.3390/agronomy13041069>